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(54) Apparatus for reproducing digital audio and video data.

(57) Digital audio and video signal are recorded on successive oblique tracks formed on a video tape, and reproduced therefrom by reproducing heads which can be movable in a direction transverse to the tracks by means of a bimorph device so that at least a plurality of tracks including one field of video and audio signals are skipped in a variable tape speed mode. Track portions provided for the audio signal are arranged at both ends of the video tracks. In a mode in which the read head ships a field the signal level of the audio signal reproduced from one end portion of the audio tracks is gradually reduced at an end of tracking by the head, while the signal level of the audio signal reproduced from other end portion of a new field track portion is gradually increased so that a cross-fade function can be performed.

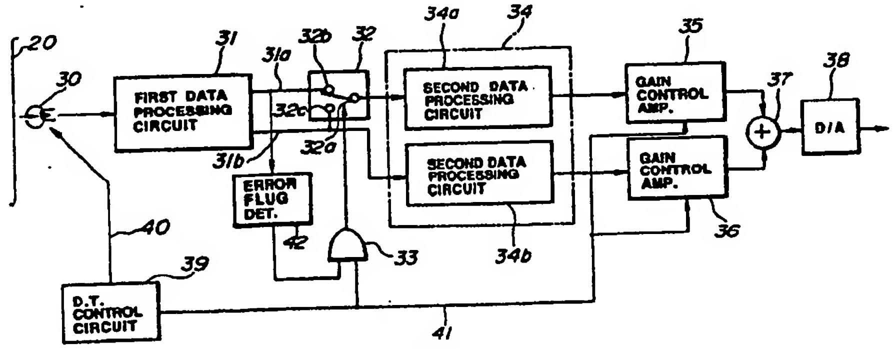

FIG.5

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APPARATUS FOR REPRODUCING DIGITAL AUDIO AND VIDEO DATA

This invention relates to an apparatus for variable-speed reproduction of audio and video data by scanning inclined recording tracks by a dynamic tracking head. It is applied for example to a digital video tape recorder of so-called D1 or D2 format in which dual digital audio data are recorded on the recording tracks.

With a so-called D1 or D2 format digital video tape recorder, digitized video and audio data are sequentially recorded on recording tracks T of the magnetic tape 10, inclined with respect to the longitudinal direction of the magnetic tape 10, as shown in Figure 2 of the accompanying drawing, by a rotary magnetic head apparatus RH shown for example in Figure 1.

The rotary magnetic head device RH shown in Figure 1 is provided with two pairs of recording heads A_1, B_1, A_2, B_2, arranged at an angular interval of 180° to each other, and two pairs of reproducing heads C_1, D_1, C_2, D_2 arranged at an angular interval of 180° to each other and orthogonally to the recording heads A_1, B_1, A_2, B_2. The recording head pairs A_1, B_1 and A_2, B_2 and the reproducing head pairs C_1, D_1 and C_2, D_2 are arranged with a height difference corresponding to one track width. In the case of the NTSC system, for example, the rotary magnetic head device RH is driven at a rotational speed of 1.5 revolutions per field to record one-field video data on three sets of tracks T_1 to T_3 on the magnetic tape 10, as shown in Figure 1.

Each inclined recording track on the magnetic tape 10 has at its central portion a video region in which video data V_{11}, V_{12}, V_{13}, V_{21}, V_{22}, V_{23}, ..., for fields F_1, F_2, ..., are recorded, and has at its leading and trailing ends audio regions in which time-base-compressed audio data, A_{11}, A_{12}, A_{13}, A_{21}, A_{22}, A_{23}, ..., are recorded dually.

For variable-speed reproduction of a tape on which audio data such as the D1 or D2 format audio data are recorded in the track direction on a block-by-block basis, there has been employed a processing system in which variable speed reproduction is performed with track jumps using a dynamic tracking head; audio signal discontinuities produced by the track jumps are compensated by interpolation or by muting, or by means of a processing system in which the rotational speed of the drum and the tape running speed are proportionally changed and all the audio and video tracks are reproduced, with the audio signals being outputted directly and the video signals being subjected to thinning-out or supplementing operations.

However, the following problems arise when performing variable speed reproduction with the D1 or D2 format digital video tape recorder.

With the former type processing system employing the dynamic tracking head, noise may be produced at the junction points on interpolation. With the muting operation, voice dropout may be audibly perceived. On the other hand, with the latter system, which changes the drum speed and tape speed proportionally, the reproducing frequency is changed due to the change in the rotational speed of the drum, so that the hardware required is increased by the necessity of time base processing of the video signals, and the voice pitch is changed. Moreover, to produce a digital voice output, it is necessary to perform the operation of changing the sampling frequency.

It is an object of the present invention to improve the audio data quality and to simplify the processing when variable speed reproduction is performed on a D1 or D2 format digital video tape recorder.

It is another object of the present invention to provide an apparatus in which reproduced audio signals of high sound quality may be produced by simple hardware without the pitch being changed during variable speed reproduction.

According to the present invention, there is provided apparatus for reproducing a digital audio and video data recorded on successive oblique parallel tracks on a video tape on which digital audio track portions are arranged at both ends of digital video track portions, the audio digital data recorded on the digital audio track portion at one end of a digital track portion being also recorded in the audio track portion at the other end portion of the video track portion of the next track so that a double recording of the audio data is accomplished, comprising:
transducing means for reproducing the digital audio and video data,
data processing means connected to said transducing means for processing the digital audio and video data and for extracting the digital audio data with an error flag data, and for providing a first and second audio data corresponding to the doubly recorded audio data,
means for controlling a position of said reproducing means in a direction transverse to the audio and video portions of the tracks so that said transducing means can skip the tracks corresponding to one field of audio and video data,
means for selecting one of said first and second audio data in response to the error flag signalling an error or control signal generated in conjunction with the skip of said transducing means,
means for controlling a gain of said first and sec-

ond audio data in response to said occurrence of the control signal so that the amplitude level of said first and second audio data is gradually decreased and increased respectively, and

means for combining output signals of said gain controlling means so that a cross-fade function of the audio data is performed during a period of occurrence of the control signal.

The invention will be further described by way of non-limitative example with reference to the accompanying drawings, in which:-

Figure 1 is a diagrammatic view showing a typical construction of a rotary magnetic head device employed in a digital video tape recorder.

Figure 2 is a diagrammatic view showing the track format of a digital video tape recorder employing the rotary magnetic head device.

Figure 3 is a diagrammatic view showing a track format on the magnetic tape and the typical scanning state by the dynamic tracking head when the present invention is applied to a digital video tape recorder to effect double speed reproduction.

Figure 4 is a diagrammatic view showing the audio data reproduced after cross-fading.

Figure 5 is a block diagram showing the construction of a digital video tape recorder to which the present invention is applied.

Figures 6A, B and C are signal waveform diagrams for illustrating the operation of the digital video tape recorder shown in Figure 5.

In an embodiment which will be explained hereinafter, the present invention is applied to an audio signal reproducing system of a digital video tape recorder having the above mentioned track format which is shown in Figure 2.

In the present illustrative embodiment of the invention, a series of audio data or voice data A_{11}, A_{12}, A_{13}, A_{21}, A_{22}, A_{23}, ... are recorded in the audio region ahead of the central video region in which video data V_{11}, V_{12}, V_{13}, V_{21}, V_{22}, V_{23}, ... for fields F_1, F_2, ..., while the same series of the audio data A_{11}, A_{12}, A_{13}, A_{21}, A_{22}, A_{23}, ... are recorded in the audio region trailing the video region with a shift corresponding to one set of the recording tracks.

That is, the audio data A_{11} is recorded in the audio region ahead of the video region of a first one T_{11} of a set of inclined recording tracks T_{11} in which the video data V_{11} of one field are recorded, while the next audio data A_{12} is recorded in the audio region at the trailing end of the video region. The audio data A_{12} is also recorded in the audio region at each end of the video region of a second one of the set of inclined recording tracks T_{12} in which the first field video data V_{11} are recorded, while the next audio data A_{13} is recorded in the audio region after the trailing end of this video region. The audio data A_{13} is also recorded in the audio region ahead of the leading end of the video region of a third one of the set of the inclined recording tracks, T_{13}, in which the first field video data V_{13} are recorded, while the audio data A_{21}, is recorded in the audio region at the trailing end of this video region. In the similar manner, the above series of audio data A_{11}, A_{12}, A_{13}, A_{21}, A_{22}, A_{23}, ... are dually recorded in the different recording track in the audio regions at the leading and trailing ends of the video regions.

Variable speed reproduction with track jumps on a field-by-field basis is performed for reproducing the video data V_{11}, V_{12}, V_{13}, V_{21}, V_{22}, V_{23} ... of the fields F_1, F_2, ... and the audio data A_{11}, A_{12}, A_{13}, A_{21}, A_{22}, ..., by scanning the inclined recording tracks of the magnetic tape 20, using a dynamic tracking head which may be displaced across the track width due to the provision of an electronically controlled bimorph, for example. The audio data before and after the track jumps are connected together by cross-fading, for example, to produce a series of reproducing audio data.

In Figure 3, the arrows and broken line show an example of the scanning state of the double-speed reproducing operation in which the inclined recording tracks T_{21}, T_{22}, T_{23} of the second field F_2, shown by hatching in Figure 3, are skipped, i.e. jumped over at the time point when the scanning of the inclined recording tracks T_{11}, T_{12}, T_{13} of the first field F_1 is terminated so as to proceed to the scanning of the inclined recording track T_{31} of the third field F_3 from the scanning of the inclined recording track T_{13} of the first field F_1.

Then, as shown in Figure 4, the reproducing audio data A_{21}, A_{31} before and after to track jump are connected with the first one-third field period after the track jump as a cross-fading period T_x, to form a series of reproduced audio data.

With the reproduced audio data A_{21}, A_{31}, connected to each other by cross-fading, the reproduced audio data A_{21} are consecutive to the previously reproduced audio data A_{13}, while the reproduced audio data A_{31} are consecutive to the subsequently reproduced audio data A_{32}, so that the cross-fading may be performed satisfactorily. Moreover, discontinuities of the reproduced audio data which occur during the cross-fade period T_x and hence are not obtrusive when heard.

By connecting the reproduced audio data before and after track jumps by cross-fading, reproduced audio data of high sound quality may be obtained by simple hardware without the pitch being changed during variable speed reproduction. The sampling frequency of the reproduced audio data need not be changed during variable speed reproduction so that the audio data may be outputted as the digital output. De-phasing of audio data caused by the five field sequence may be com-

pensated at the time of cross- fading. The phase at the junction of the reproduced audio data may be adaptively changed by the contents of the reproduced audio data to produce reproduced audio signals of higher sound quality. The construction and operation of an implementation of this point of the invention will be explained by referring to Figures 5 and 6.

Referring to Figure 5, a magnetic tape 20 has a signal recording format as shown in Figure 3. The magnetic tape is traced by a reproducing head 30 so that the video signals V_{11}, V_{12}, V_{13}, ... and audio signals A_{11}, A_{12}, A_{13}, ... are reproduced. The reproducing head 30 is controlled in its height by a dynamic tracking (DT) control circuit 39. The control of the above mentioned head jumps is performed by the dynamic tracking control circuit 39 via a wire 40 to the reproducing head 30. The video signal and the audio signal produced by the reproducing head 30 are sent to a first data processing circuit 31. This data processing circuit is formed by an equalizer, a phase locked loop, mirror square decoder and an inner code correction circuit. The mirror square coding and decoding are described in detail in United States reissue Patent 31,311. Although the data processing circuit 31 processes both video and audio signals, the present invention is concerned only with the processing of audio signals and hence the description is given herein only of the audio signals. The audio signals decoded by the processing circuit 31 and corrected as to the inner code are supplied along with data and error flags to a pair of select terminals 32b, 32c of a switching circuit 32 over wires 31a, 31b. Track outlet side audio signals shown in Figure 3 are outputted to the line 31a, while track inlet side audio signals shown in Figure 3 are outputted to the line 31b. As mentioned hereinabove, the trailing audio region of one track contains signals identical to those in the leading audio region of the next track, if there is no error, so that the aforementioned connection presents no problems. The switching circuit 32 has its stationary contact 32a controlled by the output of an AND gate 33. Thus the stationary contact 32a is connected to the select terminals 32b and 32c, for the output of the AND gate 33 being low and high, respectively. As mentioned hereinabove, audio data and an error flag is supplied on the line 31a, the error flag being high when there is an error in the audio data. This error flag is detected by an error flag detection circuit 42 and a "high" signal and a "low" signal are supplied to one input terminal of the AND gate 33. The other input terminal of the AND gate 33 is supplied from the dynamic tracking control circuit 39 with a signal which goes low only during a track jump and goes high otherwise, as shown at a in Figure 6. thus, at the time of a track jump, the output of the AND gate 33 goes low, so that the signal on the line 31a, that is, the signal from the track trailing end region, is selected by the switching circuit 32. Except during track jump, if an error is produced in the signal on the line 31a, that is, when the output of the error flag detection circuit 42 is at the high level, the output of the AND gate 33 also goes high, so that the signal on the line 31b, that is, the audio signal at the track leading region, is selected by the switching circuit 32.

The audio signal thus selected is transmitted to a second data processing circuit 34, which includes above all an outer code correction circuit and a deshuffle circuit. Although two second data processing circuits 34a, 34b are shown in Figure 5 as being present separately, the data processing operation is performed in effect as a time-divisional operation, so that only one processing circuit need actually be employed. These second data processing circuits 34a, 34b are supplied with an output signal of the switching circuit 32 and a signal over the line 31b, respectively. The audio signals processed by these signal processing circuits 34a, 34b are supplied to gain control amplifiers 35, 36, respectively. the gain of each of the gain control amplifiers are changed during the time the track jump control signal (A in Figure 6) is at a low level. Thus, as shown at B in Figure 6, the gain of the gain control amplifier 35 is changed gradually from "1" to "O" during the track jump period T_x. with the gain equal to 1, the input signal is outputted directly, whereas, with the gain equal to O, no input signal is outputted. Except during jumping, the gain control amplifier 35 has a gain equal to "1", as shown at B in Figure 6. Conversely, the gain of the gain control amplifier 36 is adapted to be changed gradually from "O" to "1" during track jump period T_x, as shown at C in Figure 6. The gain control amplifiers 35, 36 are controlled by the track jump control signal, shown at A in Figure 6, supplied from the dynamic tracking circuit 39 over line 41. Thus the level of the output signal from the gain control amplifier 35 is gradually reduced during the track jump period T_x as shown at A_{21} in Figure 4, whereas the level of the output signal gain control amplifier 36 is increased as shown at A_{31} in Figure 4. The output signals from these gain control amplifiers 35, 36 are summed together in a mixing circuit 37, so that the signal A_{21} decaying gradually during the track jump period T_x and the signal A_{31} increasing gradually during the same period are ultimately mixed with each other, that is, cross-faded, as shown at B in Figure 4, before being supplied to a digital-to-analog converter 38. It is noted that the arrangement of the present invention shown in Figure 5 is shown in a hardware block diagram only for assisting the understanding of the

present invention, and that, in practice, it may be composed of a micro-computer and peripheral circuits, such as additional ROMs or RAMs. It is therefore apparent that a construction of Figure 5, uses a micro-computer, is also comprised within the scope of the present invention.

Claims

1. Apparatus for reproducing a digital audio and video data recorded on successive oblique parallel tracks on a video tape on which digital audio track portions are arranged at both ends of digital video track portions, the audio digital data recorded on the digital audio track portion at one end of a digital track portion being also recorded in the audio track portion at the other end portion of the video track portion of the next track so that a double recording of the audio data is accomplished, comprising:
transducing means for reproducing the digital audio and video data,
data processing means connected to said transducing means for processing the digital audio and video data and for extracting the digital audio data with an error flag data, and for providing a first and second audio data corresponding to the doubly recorded audio data,
means for controlling a position of said reproducing means in a direction transverse to the audio and video portions of the tracks so that said transducing means can skip the tracks corresponding to one field of audio and video data,
means for selecting one of said first and second audio data in response to the error flag signalling an error or control signal generated in conjunction with the skip of said transducing means,
means for controlling a gain of said first and second audio data in response to said occurrence of the control signal so that the amplitude level of said first and second audio data is gradually decreased and increased respectively, and
means for combining output signals of said gain controlling means so that a cross-fade function of the audio data is performed during a period of occurrence of the control signal.

2. The apparatus according to claim 1, wherein said data processing means, selecting means and gain control means are performed by using a digital signal processing circuit.

3. The apparatus according to claim 2, wherein said digital signal processing circuit includes a micro-computer.

4. The apparatus according to claim 3, in which an error flag detection circuit is further included for generating the error flag.

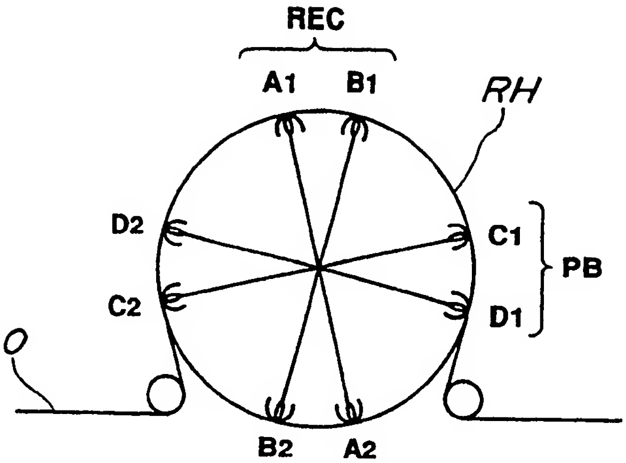
REC
A1
B1
RH
D2
C1
PB
C2
D1
10
B2
A2

FIG.1

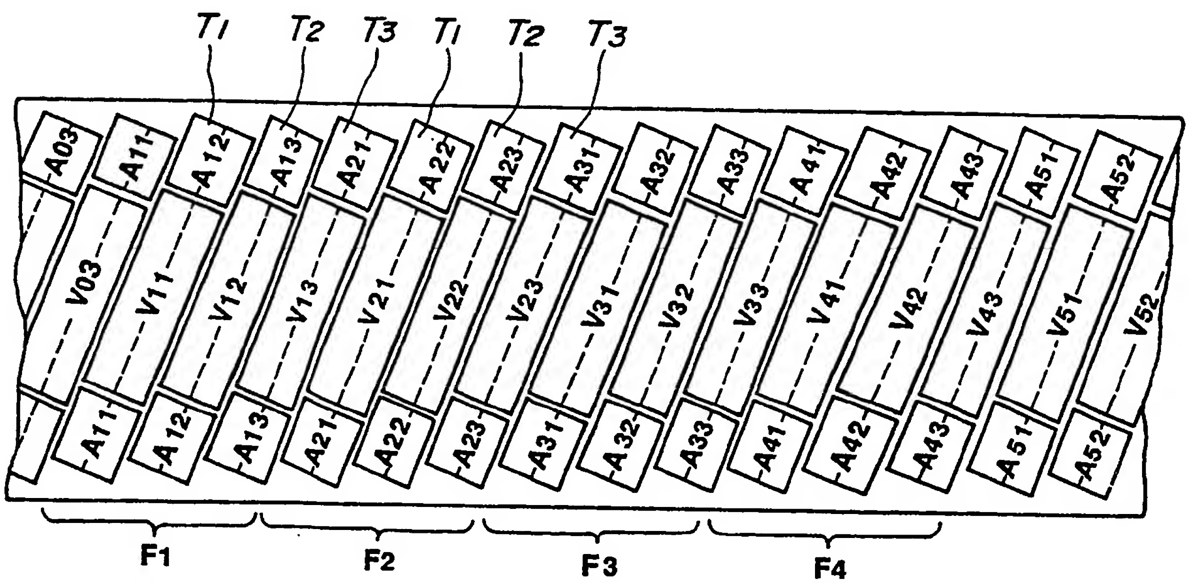
T1
T2
T3
T1
T2
T3
A03
A11
A12
A13
A21
A22
A23
A31
A32
A33
A41
A42
A43
A51
A52
V03
V11
V12
V13
V21
V22
V23
V31
V32
V33
V41
V42
V43
V51
V52
A11
A12
A13
A21
A22
A23
A31
A32
A33
A41
A42
A43
A51
A52
F1
F2
F3
F4

FIG.2

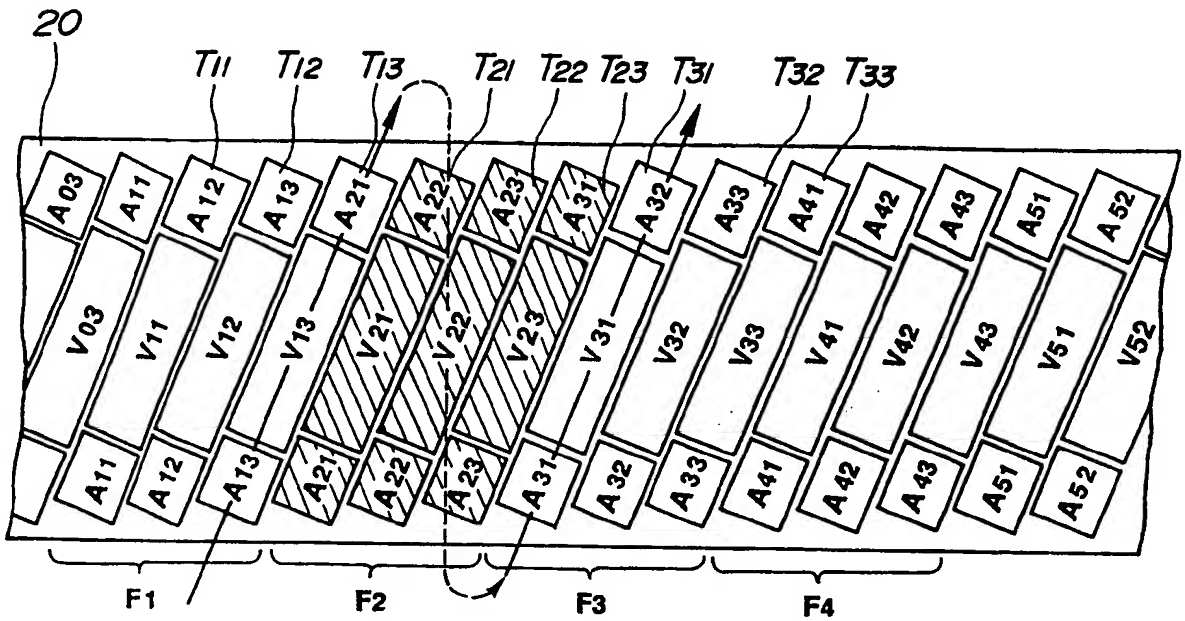
20
T11
T12
T13
T21
T22
T23
T31
T32
T33
A03
A11
A12
A13
A21
A22
A23
A31
A32
A33
A41
A42
A43
A51
A52
V03
V11
V12
V13
V21
V22
V23
V31
V32
V33
V41
V42
V43
V51
V52
F1
F2
F3
F4

FIG. 3

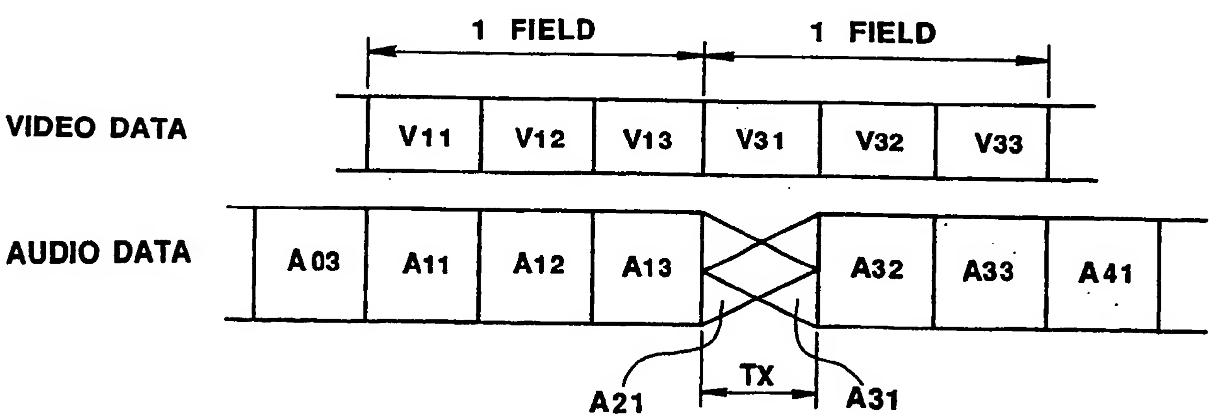
1 FIELD
1 FIELD
VIDEO DATA
V11
V12
V13
V31
V32
V33
AUDIO DATA
A03
A11
A12
A13
A32
A33
A41
A21
TX
A31

FIG. 4

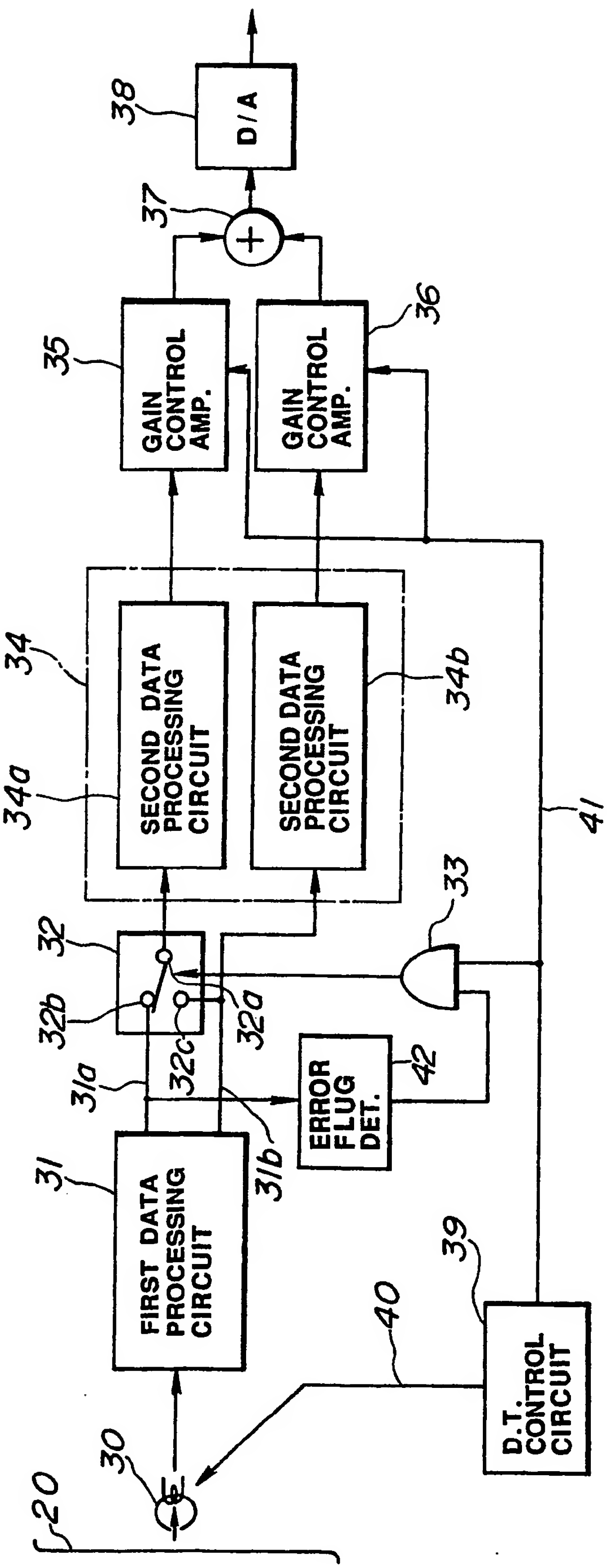

FIG.5

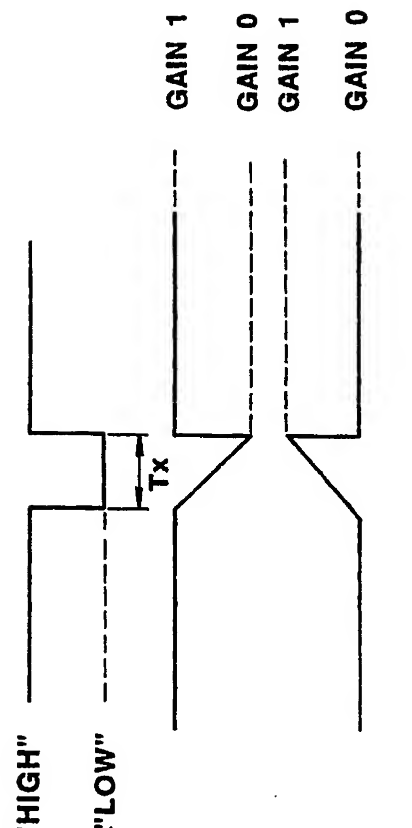

FIG.6A

FIG.6B

FIG.6C

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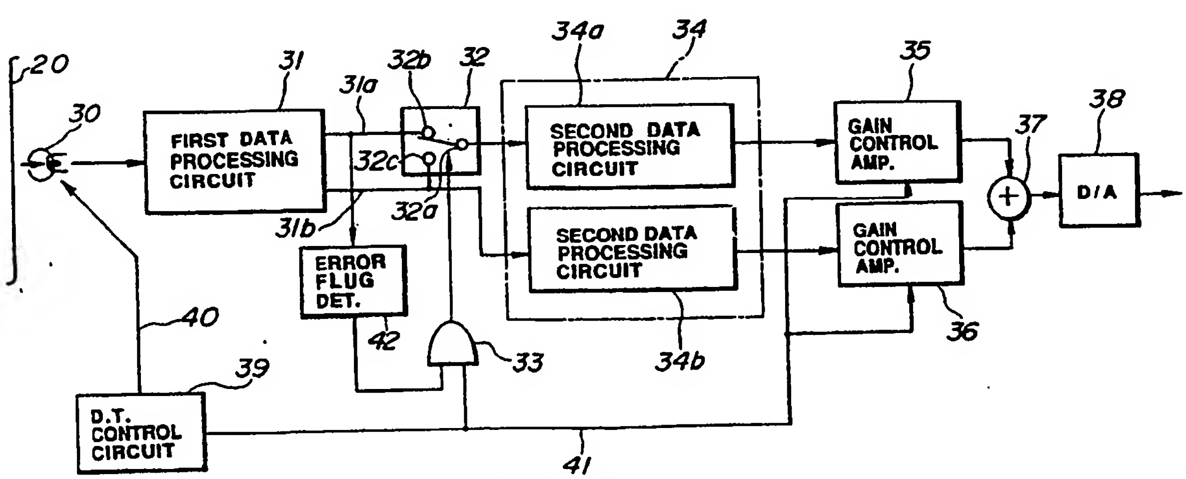

FIG.5

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European
Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 31 2259

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	FERNSEH & KINOTECHNIK, vol. 38, no. 7, July 1984, pages 281-286; J. HEITMANN: "Digitale Videoaufzeichnung Grundlagen . Standardisierung . Entwicklung" * Figures 2,3; sections 6,7 *	1-4	H 04 N 5/93 H 04 N 5/92
Y	GB-A-2 092 814 (SONY) * Abstract; figures 1,9; page 1, right-hand column, lines 76-93; page 4, left-hand column, lines 7-35 *	1-4	
A	US-A-4 751 590 (WILKINSON) * Abstract; figures 2,3; column 3, lines 2-58 *	1-4	
A	US-A-4 717 972 (HEITMANN) * Abstract; figure 1; claim 5 *	1	
A	S.M.P.T.B. JOURNAL, vol. 97, no. 3, March 1988, pages 182-193, White Plains, NY, US; R. BRUSH: "Design considerations for the D-2 NTSC composite DVTR" * Page 186, paragraph: "Error control strategy"; page 193, section: "Audio segment timing and editing"; figure 18 *	1	**TECHNICAL FIELDS SEARCHED (Int. Cl.5)**
A	EP-A-0 180 445 (SONY) * Abstract; pages 1,2 *	1	H 04 N
A	WIRELESS WORLD, no. 1850, May 1984, pages 55-58, Sheepen Place, Olchester, GB; J.R. WATKINSON et al.: "Variable-speed video playback"		

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	04 June 91	GIANNOTTI P.

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
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